Examining the Role of University Research Labs in Secondary Teacher Education

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Abstract

Teachers spend hours in professional development, supposedly designed to improve teaching in the classroom, but most professional development lacks a mechanism that can be used to bring relevance into the classroom. Moreover, the existing curriculum lacks material that motivates students to understand the "real-world" importance of science. To build a repertoire of interesting lesson plans, teachers must venture outside the classroom. For science teachers, first-hand laboratory research experience is a potential source of professional knowledge that can translated to classroom enrichment. Working in an academic research lab, and spending time with the lab's personnel gives an insight into the ups and downs of the scientific world. Additionally, through learning and practicing research techniques such as experimental design, solution preparation and gas chromatography-mass spectrometry, it is envisioned that my ability to communicate science to my students will be improved. By reading, understanding and presenting novel research in the field of biomaterials, I am also able to pique the interest of my students. Specifically, the use of ionic liquids to produce biofuels from switchgrass is relevant to Unit 4 of my Environmental Sustainability course. To collect information, I have conducted one on one meetings with the PI, attended weekly lab group meetings and interviewed a postdoctoral researcher, one high school student, and 4 undergraduate students working in the Queens University Chemistry Lab in Summer 2019. The ultimate goal of my interviews are to extract information from researchers that would be interesting to present to my students to encourage participation in STEM disciplines.

Objectives

- Determine the relevance of field and laboratory work to science teachers
- Interview a range of people working in a chemistry lab, from high school students all the way up to the PI
- To acquire and interpret quantifiable data to support my theory that lab and field work can directly increase the quality of instruction in the science classroom
- To acquire lab techniques by working in the chemistry lab
- To contribute to the lab culture set up by the PI by attending weekly lab meetings

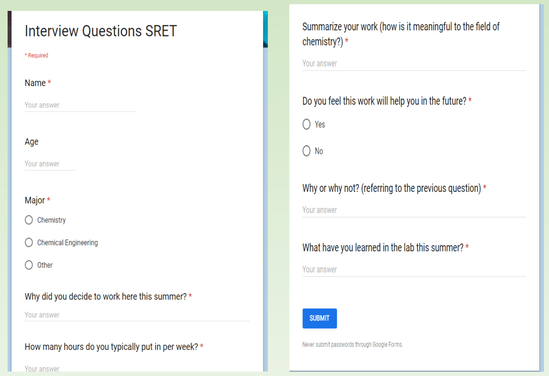
Figures 1-3. All members of the chemistry laboratory team under the direction of Dr. Aaron Socha (PI, not pictured); interview with a high school student and working with the rotovap in the lab.

Methods

Over the course of five weeks, a total of eight persons working in the lab were interviewed. The interview was in two parts: one in person and the other consisted of a questionnaire. See below for the google form participants were asked to fill out. Questions ranged from stating their name, age, major, and education status to asking the person to explain the relevance of their work and how their work would make a significant contribution to the field of chemistry. The in person interview was so I could truly get a feel about the lab employee's feel and attitude for their work and to clear up any clarifying questions I may have had. I also assisted the PI in the laboratory with current research on ionic liquids. Work included analyzing results from High Pressure Liquid Chromatography (HPLC) and using the rotary evaporator (rotovap) to dry ionic liquids. Also, weekly lab meetings were held to present current projects, clear up any misunderstandings and practice presentations. Data has been quantified and analyzed based on verbal interviews and filling out the interview questionnaire.

Link to Questionnaire and image

https://forms.gle/cvWTJi4UgWfihTQY6



Figures 4-5 Screenshot of the questionnaire that lab employees completed via Google Forms.

Quotes From Interview: Question-Summarize your work.

-"Our research pertains to the "green chemistry" movement in which chemists are developing more environmentally responsible and sustainable solutions to industrial processes." –Undergraduate Student

-"I am working on the purification of vanillin from depolymerized lignin." – High School Student

-"My research focuses on developing new Ionic liquid using biomaterials and biomass. It will dramatically reduce the cost of ionic liquid synthesis." –Posdoctoral Fellow

-"We are working to apply the Mannich reaction to the synthesis of ionic liquids and starting a few experiments to determine the rate of this reaction in the coming weeks." –Undergraduate Student

-"My work is focused on the discovery and use of natural products for applications involving bio-based materials. For example, we are actively pursuing the optimization of ionic liquid structures from lignin-derived starting materials. The ionic liquids are then tested for their ability to solubilize polymers, such as cellulose, and convert bioenergy crops such as switchgrass and corn stover into fermentable sugars for biotechnology. – Principal Investigator

Results

From the interviews I conducted, I have found that high school students spend on average 15 hours per week, undergraduate students spend on average 25 hours per week, and graduate/postgraduate spend on average 45 hours per week. Time spent in the lab is a direct correlation of the career path and age of the interviewee. The youngest students (high school) have other projects going and are involved in college preparation and returning to school in the fall. Undergraduate students are committed but have other obligations that include internships and summer school classes. Graduate and beyond have a full commitment and have made this field their career choice so logic would dictate that they spend the most time in the lab.

As far as relevance. I found that although all three groups could explain their projects, some of the the undergraduate students have trouble explaining the relevance and contribution to the field of chemistry. As far as enhancing my instruction, lab and field work is essential to a teacher remaining relevant. If we rely solely on curriculum developed by the North Carolina Department of Public Instruction and Project Lead the Way, the material is outdated by the time it is published. Being on the cutting edge of STEM is essential to preparing students for 21st century learning. Techniques honed in lab can help improve practical laboratory instruction for students as well. It has been my experience that students do not get enough lab instruction in high school or even at the undergraduate level in college. I personally did not master the microscope properly until graduate school

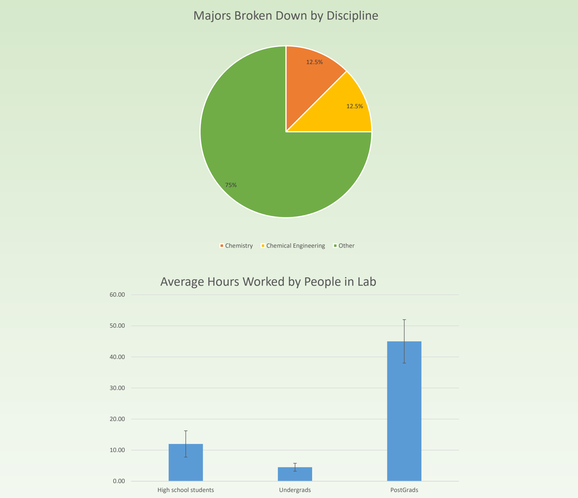


Chart 1 displays the majors broken down by discipline of people who work in the lab. Chart 2 displays the number of hours spent in lab per week by each level (high school, undergrad, grad and beyond standard deviation is also included

Figures 6-7. Word clouds summarizing why employees are working in the lab and what they have learned. Taken from the surveys. Font size correlates to the number of times word was mentioned.

Quotes from Interview-Question What have you learned this summer?

- "University labs are much different than a high school chemistry class. In high school, many of the experiments are easy to do, been performed many times before, and come with a set of instructions. However, in actual research, often times the experiments are new without a detailed set of guidelines, and the chemist does not know if they will produce the desired result." – High School Student
- "That teaching by demonstration is best for allowing people to continue to learn on their own and applying what they learned to new problems." –Principal Investigator

Conclusions

I have concluded that experience in the lab for a teacher in a science field is quintessential to enhancing the delivery of instruction in the classroom and helping bring relevance to the classroom. Teachers should endeavor to gain relevant experience outside of the classroom whenever possible to increase relevance and stay up to date in the classroom. I have also learned that directly placing high school students in the lab to work with a PI significantly increases their college readiness to do lab work that is graded. Trends in the word clouds show direct correlation between what interviewees hoped to accomplished and what they accomplished. Primary words used went from "experience" to "experiment", suggesting that they achieved at least one of their objectives this summer. This shows that lab experience is valuable, especially since 100% of people interviewed felt their work was meaningful. Future plans include to continuing to seek field work whenever possible both at the University and Professional level.

References

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